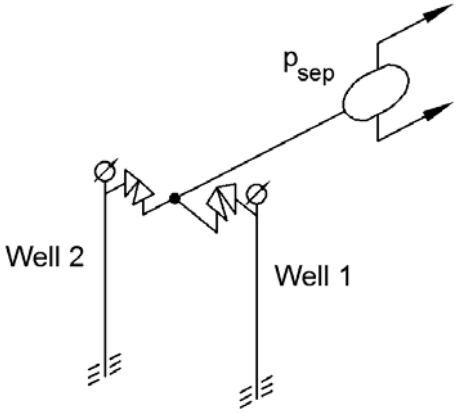
Where Δp [bara], q in [m^3/d]. Assume a constant pump efficiency (η) of 0.6. Assume an oil formation volume factor (Bo) at the pump suction of 1.2 m^3/Sm^3.

PROBLEM 4 (18 POINTS). Network solving.

Consider the gas field with two wells, a manifold a pipeline and a separator shown in the figure below. The wellhead of the wells are very close to the junction so it can be safely assumed that the wellhead pressure and junction pressure are equal when the choke is open.



Each well has a different H2S concentration as provided in the table below:

Well name	H2S concentration [mg/Sm^3]
Well 1	2.6
Well 2	10.0

The wellhead performance relationship (WPR, available pressure at the wellhead) of each well can be expressed with the following equation:

$$q = C_{wh} \cdot \left({p_{whs}}^2 - {p_{wh}}^2 \right)$$

Where p_{whs} is the static wellhead pressure recorded when the well is shut-in. The values for both wells are provided in the table below:

Well Name	C_{wh} [Sm^3/d/bara^2]	P_{whs} [bara]
Well 1	60	150
Well 2	100	135

The pipeline performance relationship (PPR, required pressure at the junction) can be expressed with the following equation:

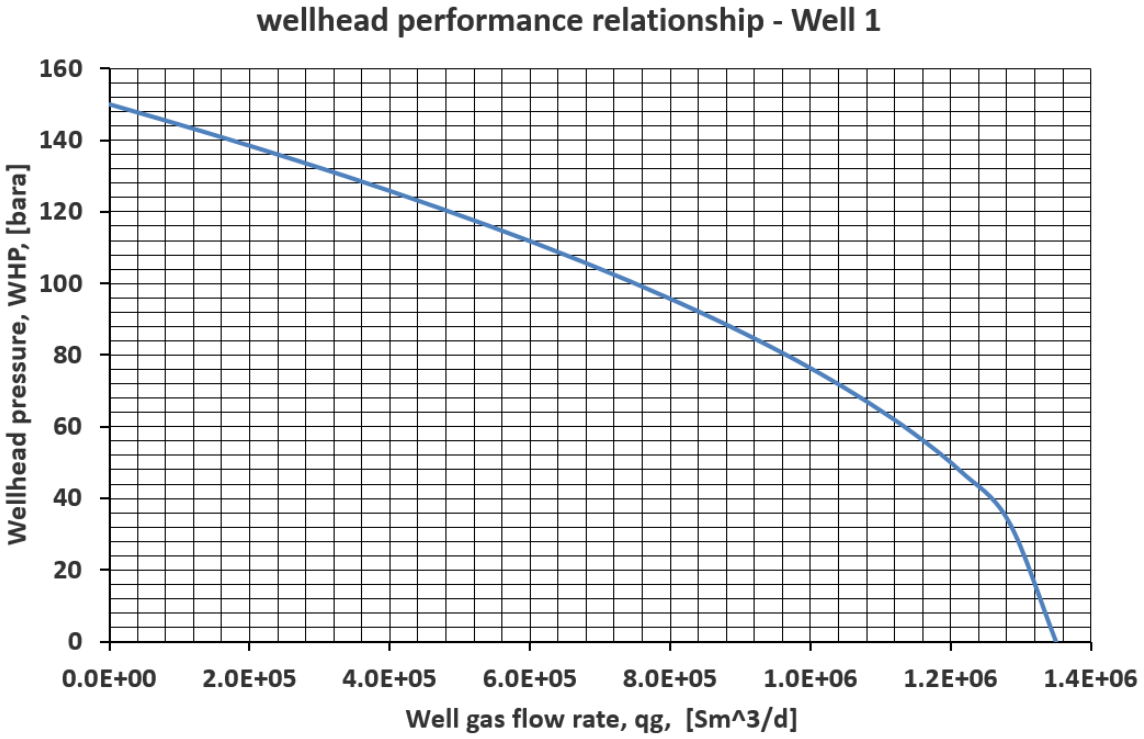
$$q = C_{pl} \cdot \left({p_j}^2 - {p_{sep}}^2 \right)^{0.5}$$

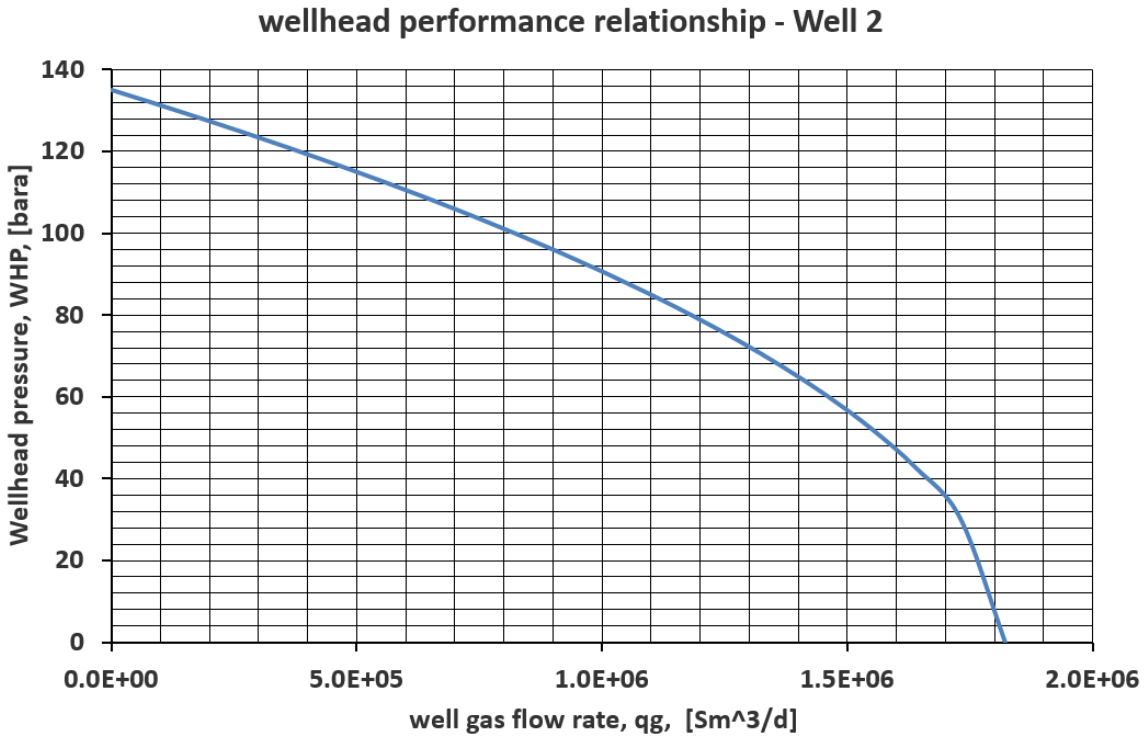
Where
C_{pl} = 45 000 [Sm^3/d/bar^2]
p_{sep} = 30 [bara]

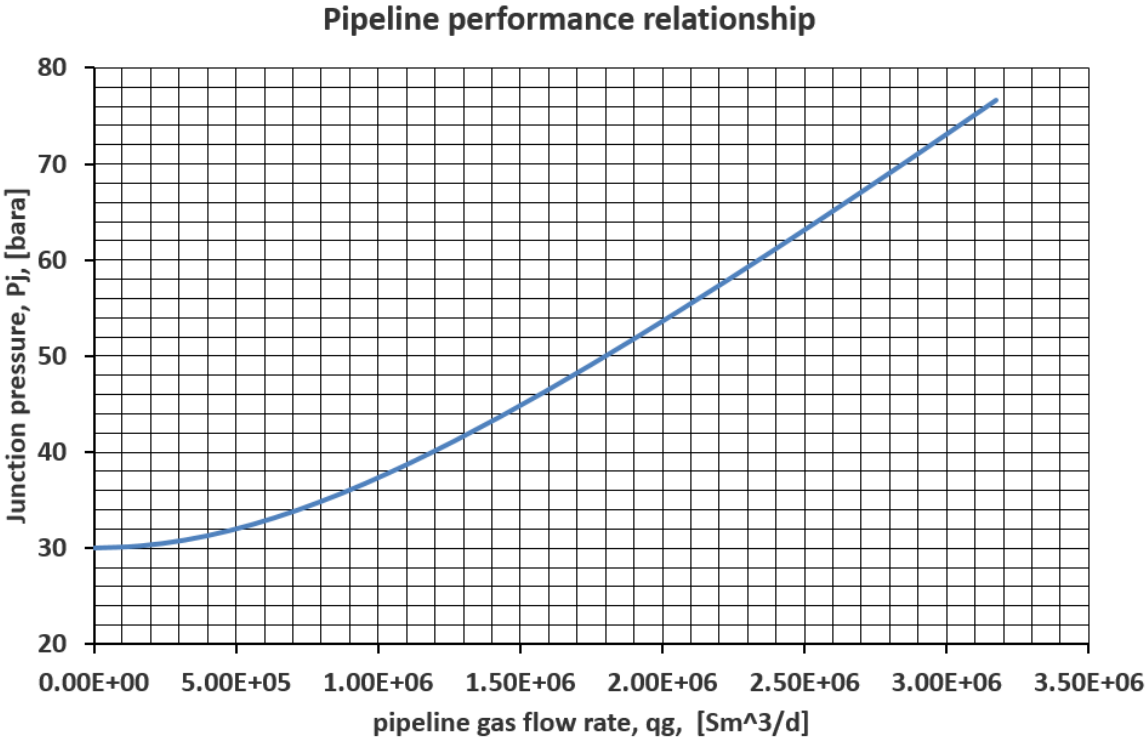
You can also solve this problem graphically, the available and required pressure curves are provided at the end of the exercise.

You tasks are:

Task 1 (9 POINTS). Calculate the operating flow rates when the chokes are fully open. Verify if the H2S concentration of the field is higher than the maximum value allowed (5.7 mg/Sm^3)
Task 2. (6 POINTS) If the H2S constraint is violated, please find an operational point that does not violate the H2S constraint (by choking one or two wells). Hint: Fix the rate on both wells. Report the pressure drop across the chokes.
Task 3. (3 POINTS) Will it be worth to apply model-based optimization to this problem?. Explain your answer. If yes, please explain how will you set up the optimization problem, what is the objective, what variables will you change and what are the constraints (In excel). Please specify where will you locate the input, output and in which cells are the objective, constraints and variables.




wellhead performance relationship - Well 2
Wellhead pressure, WHP, [bara]
140
120
100
80
60
40
20
0
0.0E+00
5.0E+05
1.0E+06
1.5E+06
2.0E+06
well gas flow rate, qg, [Sm^3/d]


Pipeline performance relationship
Junction pressure, Pj, [bara]
80
70
60
50
40
30
20
0.00E+00
5.00E+05
1.00E+06
1.50E+06
2.00E+06
2.50E+06
3.00E+06
3.50E+06
pipeline gas flow rate, qg, [Sm^3/d]